

AMENDMENTS TO THE CLAIMS

This listing of claims will replace all prior versions and listings of claims in the application:

LISTING OF CLAIMS:

1. (currently amended): A vehicle running state estimation method comprising ~~the steps of:~~
detecting ~~the~~ a vibration level of a portion below a ~~the~~ spring of a running vehicle;
and
estimating the running state of the vehicle by determining at least one of ~~the~~ a condition of a road surface on which the vehicle is running and ~~the~~ a running state of each tire,
wherein said determining is based on the detected vibration level. ~~based on the detected vibration level to estimate the running state of the vehicle.~~
2. (currently amended): The vehicle running state estimation method according to claim 1, wherein ~~the~~ a waveform of time changes in the vibration level is detected and the condition of the ~~a~~ road surface on which the vehicle is running is estimated from a vibration level at a predetermined position of ~~the~~ is waveform or for a predetermined time range.
3. (currently amended): The vehicle running state estimation method according to claim 1, wherein ~~the~~ a frequency of the detected vibration level is analyzed to calculate a vibration level at a predetermined frequency band and the condition of ~~a~~ the road surface ~~on which the vehicle is running~~ is estimated from the calculated vibration level.
4. (currently amended): The vehicle running state estimation method according to claim 1, wherein the frequency of the ~~above~~ detected vibration level is analyzed, at least two vibration levels at different frequency bands are calculated, an operation is carried out on the

~~above~~~~at least two~~ calculated vibration levels, and the condition of ~~the~~ a road surface ~~on which~~ the vehicle is running is estimated from the computed value.

5. (currently amended): The vehicle running state estimation method according to claim 1, wherein ~~the~~ vibration levels of at least two points of a portion below the spring of a running vehicle are detected to calculate ~~the~~ a vibration transmission level of the portion below the spring of the vehicle, and the condition of ~~the~~ a road surface ~~on which~~ the vehicle is running is estimated from the calculated vibration transmission level.

6. (currently amended): A vehicle running state estimation apparatus for estimating running state of a vehicle based on road surface conditions, the estimation apparatus comprising:

means of detecting ~~the~~ a vibration level of a portion below ~~the~~ a spring of a running vehicle;

means of computing ~~the~~ waveform of time changes in the vibration level; and road surface condition estimation means for estimating ~~the~~ a condition of a road surface on which the vehicle is running from ~~the~~ a vibration level at a predetermined position of the waveform or for a predetermined time range.

7. (currently amended): The vehicle running state estimation apparatus according to claim 6 ~~which~~ further comprising means of calculating the vibration level of at least one of a tire leading edge portion, tire ground contact portion and tire trailing edge portion of the waveform.

8. (currently amended): A vehicle running state estimation apparatus comprising:
means of detecting a ~~the~~ vibration level of a portion below ~~the~~ a spring of a running vehicle;

means of calculating a vibration level at a predetermined frequency band by analyzing ~~the~~ frequency of the detected vibration level; and

road surface condition estimation means for estimating the condition of ~~the~~ a road surface on which the vehicle is running from the calculated vibration level,

wherein the running state of the vehicle is estimated based on the condition of the road surface received from the road surface condition estimation means.

9. (currently amended): A vehicle running state estimation apparatus comprising:
means of detecting ~~the~~ a vibration level of a portion below ~~the~~ a spring of a running vehicle; and

road surface condition estimation means for estimating ~~the~~ condition of a road surface ~~on which the vehicle is running~~ from a value obtained by carrying out an operation on at least two vibration levels at different frequency bands by analyzing the frequency of the ~~above~~ detected vibration level,

wherein the running state of the vehicle is estimated based on the condition of the road surface received from the road surface condition estimation means.

10. (currently amended): A vehicle running state estimation apparatus for estimating a running state of a vehicle based on a condition of a road surface comprising:

means of detecting ~~the~~ vibration levels of at least two points one of a portion below ~~the~~ a spring of ~~the~~ a running vehicle;

means of calculating a vibration transmission level at a predetermined frequency band between said ~~the~~ at least two of ~~the~~ vibration detection points; and

road surface condition estimation means for estimating the condition of ~~the~~ a road surface on which the vehicle is running from the calculated vibration transmission level.

11. (currently amended): The vehicle running state estimation apparatus according to claim 10, wherein a vibration buffer member is interposed between ~~the said~~ at least two vibration detection points.

12. (currently amended): The vehicle running state estimation apparatus according to claim 8, wherein a road surface friction coefficient μ at a time of running the vehicle is estimated based on a relationship between the a relationship between road surface friction coefficient μ obtained from the braking distances of the vehicle under various road conditions at different speeds and at least one of the calculated vibration level at said a predetermined frequency band and, the computed value of vibration level or a calculated vibration transmission level is obtained previously and the road surface friction coefficient μ at the time of running is estimated based on the relationship.

13. (currently amended): The vehicle running state estimation apparatus according to claim 8, wherein the frequency band is a band including ~~the~~ frequency of natural vibration of a tire tread land portion.

14. (currently amended): The vehicle running state estimation apparatus according to claim 8, wherein a threshold value is set for the vibration level, and the surface of ~~the~~ a road is estimated to be in a low friction condition when the calculated vibration level exceeds the threshold value.

15. (currently amended): The vehicle running state estimation apparatus according to claim 14, wherein the threshold value can be changed.

16. (currently amended): The vehicle running state estimation apparatus according to claim 6 which further comprises a vehicle speed detection means to estimate the condition of a road surface based on vehicle speed.

17. (currently amended): ~~A-The~~ vehicle running state estimation apparatus comprising ~~the vehicle running state estimation apparatus~~ of claim 6, further comprising: means of judging ~~the~~ slipperiness of ~~the~~ a road surface based on the condition of the road surface estimated by the road surface condition estimation means; and warning means for giving a warning when it is judged that the condition of the road surface is slippery.

18. (currently amended): The vehicle running state estimation apparatus according to claim 17, which further comprises: vehicle speed detection means to change decision on the slipperiness of ~~the~~ a road surface and warning level based on vehicle speed.

19. (withdrawn): A vehicle running state estimation apparatus comprising: means of detecting the vibration level of a portion below the spring of a running vehicle; means of estimating the air pressure of each tire by calculating the frequency of natural vibration of the tire from a vibration level at a frequency band of 200 Hz or less of the detected vibration level; and tire running state estimation means for estimating the condition of each tire while running from the estimated air pressure of the tire.

20. (withdrawn): The vehicle running state estimation apparatus according to claim 19 which further comprises tire pressure monitoring means for monitoring the pressure of each tire while running using the estimated air pressure of the tire.

21. (withdrawn): The vehicle running state estimation apparatus according to claim 20 which further comprises warning means for warning a passenger of a reduction in the

pressure of the tire when the air pressure monitored by the tire pressure monitoring means falls below a predetermined value.

22. (withdrawn): A vehicle running state estimation apparatus comprising:
means of detecting the vibration level of a portion below the spring of a running vehicle;
tire revolution speed detection means;
tire running state estimation means for estimating the state of each tire while running by calculating the average value of vibration level changing by the revolution speed of the tire at a frequency band of 100 Hz or less of the detected vibration level; and
tire trouble detection means for judging that the tire is abnormal when the calculated average value of vibration level exceeds a preset reference value.

23. (withdrawn): The vehicle running state estimation apparatus according to claim 22, wherein the reference value is set to a range of 1.2 to 5 times the vibration level at a reference decision frequency F_n when the vehicle runs at a predetermined speed V while the tire is not abnormal:

reference decision frequency $F_n = n \times V/(2\pi r)$
wherein r is the rolling radius of the tire, and n is 1, 2, 3, ...

24. (withdrawn): The vehicle running state estimation apparatus according to claim 23, wherein the reference value can be changed.

25. (currently amended): The vehicle running state estimation apparatus according to claim 6, ~~which further comprises~~ a transmitter for transmitting the output of the vibration detection means for calculating a time change in the vibration level or a vibration level at a predetermined frequency band.

26. (currently amended): The vehicle running state estimation apparatus according to claim 6 further comprising a power generating unit ~~which is mounted to on~~ a tire wheel, wherein the power generating unit generates power by ~~the~~ rolling of each tire and supplies power for at least one of driving the vibration detection means ~~or power for and~~ amplifying ~~the~~ output of the vibration detection means.

27. (currently amended): A vehicle control apparatus comprising vehicle control means for controlling the running state of a vehicle based on the condition of ~~the~~ a road surface estimated by the vehicle running state estimation apparatus of claim 6 ~~and/or the running state of each tire~~.

28. (currently amended): The vehicle control apparatus according to claim 27 which comprises vehicle speed detection means to control the running state of ~~the~~ a vehicle based on vehicle speed.

29. (currently amended): The vehicle control apparatus according to claim 27, wherein the vehicle control means controls ~~the~~ locked state of each wheel.

30. (currently amended): The vehicle control apparatus according to claim 27, wherein the vehicle control means controls ~~the~~ attitude of the a vehicle.

31. (currently amended): The vehicle control apparatus according to claim 27, wherein the vehicle control means controls ~~the~~ air pressure of each tire.

32. (currently amended): The vehicle control apparatus according to claim 27, wherein the vehicle control means controls ~~the~~ idling state of each wheel.

33. (currently amended): The vehicle control apparatus according to claim 27, wherein the vehicle control means changes the inter-vehicle distance set value of an automatic driving system.

34. (currently amended): A tire wheel comprising: the vehicle running state estimation apparatus for estimating the running state of the vehicle by detecting the vibration level of the portion below the spring of a running vehicle as set forth in claim 6, and a power generating unit for generating power by the rolling of each tire and supplying power to the vehicle running state estimation apparatus.

35. (original): The tire wheel according to claim 34, wherein the vehicle running state estimation apparatus is mounted to the tire wheel.

36. (previously presented): The tire wheel according to claim 34, wherein the power generating unit comprises a rotor magnetized and rotated by the rolling of each tire, a stator made from a high magnetic permeability material and adjacent to the rotor and a power generating coil installed within a magnetic circuit including the rotor and the stator.

37. (original): The tire wheel according to claim 36, wherein the power generating unit comprises means of accumulating electromotive force generated in the power generating coil.

38. (previously presented): The tire wheel according to claim 36, wherein the rotor is turned by rotating an unbalance weight the gravity center of the rotary cone of which is eccentric to a rotary shaft by the rolling of each tire.

39. (previously presented): The tire wheel according to claim 36, wherein an air stream generated by the rolling of each tire is introduced into the power generating unit and the

rotor is turned by the introduced air stream.